WE CLAIM:

1. A route calculation program for use in a navigation system used with a map database stored on a computer readable storage medium, the route calculation program adapted to find a solution route between a first location on a road network in a geographic region and a second location on the road network in the geographic region, said route calculation program comprising:

at least one search tree adapted to hold a plurality of gate data structures, each of said gate data structures representing a physical position on the road network in the geographic region represented by said map database and a direction from said position to another location on said road network in said geographic region, said at least one search tree associated with said first location; and

a priority queue referencing said gate data structures in said at least one search tree and assigning a priority to one of said gate data structures;

wherein said route calculation is adapted to expand said one of said gate data structures to determine successor gate data structures thereof and to compare each of said successor gate data structures to gate data structures associated with said second location.

2. The invention of Claim 1 further comprising a focus, said focus representing a physical location relative to which said gate data structures in said at least one search tree are evaluated to determine said priority.

3. The invention of Claim 2 wherein said focus is configurable.

4. The invention of Claim 1 wherein said route calculation program is further adapted to invoke a search algorithm to perform said evaluation for assigning said priority.

5. The invention of Claim 4 wherein said algorithm is configurable.

6. The invention of Claim 4 wherein said search algorithm is one of the A* algorithm and the Dykstra algorithm.

1 7. The invention of Claim 1 wherein said map database includes a plurality

2 of road segment data records each of which represents a road segment of said road

3 network,

4   wherein said plurality of gate data structures comprise seed gate data structures

5 and other-than-seed gate data structures,

6   wherein the physical position represented by each of said other-than-seed gate

7 data structures corresponds to an endpoint of a road segment, and

8   wherein the physical position represented by each of said seed gate data

9 structures corresponds to a position along a road segment between endpoints thereof.

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11 8. A route calculation tool program for use in a navigation system used

12 with a map database that represents a road network in a geographic region, said route

13 calculation tool program comprising:

14   a first search tree associated with one of an origin and a destination and a

15 second search tree associated with the other of the origin and the destination, wherein

16 each of said search trees includes gate data structures each of which represents a

17 position on a road network represented by said map database and a direction by which

18 said position is accessible in a desired direction of travel;

19   wherein the route calculation program includes at least one priority queue that

20 references one of said gate data structures in one of said search trees; and

21   wherein said route calculation tool program expands said one gate data

22 structure referenced by said priority queue to form successor gate data structures

23 thereof whereby a solution route is obtained by at least one gate data structure in said

24 first search tree corresponding to at least one gate data structure in said second search

25 tree.

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27 9. The invention of Claim 8 wherein each of said search trees further

28 comprises a focus, each focus representing a physical location relative to which each of

29 said gate data structures in its respective search tree is evaluated to determine said

30 priority.

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32 10. The invention of Claim 9 wherein said focus is configurable.

11.   The invention of Claim 9 wherein the physical location represented by the focus of said first search tree corresponds to a position represented by a gate data structure in said second search tree.

12.   In a route calculation program, a computer readable locus data structure means for use with a map database, wherein the map database includes a plurality of data records representing segments of roads in a geographic region, said computer readable locus data structure means adapted to identify a location along one of said segments of roads, said computer readable locus data structure means comprising:

a first locus data structure portion adapted to identify one of said plurality of data records, wherein said one of said plurality of data records represents a road segment along which the location can be accessed;

a second data structure portion adapted to identify a subsegment of the road segment represented by the one of said data records identified in said first data structure, wherein said subsegment represents a position between endpoints of the road segment via which the location can be accessed in a desired direction; and

a third data structure portion adapted to identify a side of the road segment represented by the one of said data records identified in said first data structure, wherein said side represents a side of the road segment via which the location can be accessed at the subsegment represented by the second data structure portion.

13.   In a route calculation program, a computer readable waypoint data structure means for use with a map database, wherein the map database includes a plurality of data records representing segments of roads in a geographic region, said computer readable waypoint data structure means adapted to identify a waypoint wherein said waypoint represents a location along a route to be calculated by the route calculation program and through which said route is constrained to pass, wherein said waypoint represents one of an origin, a destination, and an intermediate stop along said route, and further wherein said computer readable waypoint data structure means is adapted to provide for defining access from or to said waypoint, wherein said waypoint data structure means comprises:

1   at least one locus data structure means as set forth in Claim 12.

2

3   14.   A method of operating a navigation system to identify a location in a

4 geographic region, wherein said navigation system uses a map database that includes a

5 plurality of data records each of which represents a road segment in the geographic

6 region, wherein each of said data records is associated with two nodes each of which

7 represents a location of an endpoint of the road segment represented by the data

8 record, the method comprising the steps of:

9   identifying one data record of said plurality of data records, said one data

10 record representing a road segment along which said location is accessible in a desired

11 direction of travel;

12   identifying a subsegment of the one data record, said subsegment representing

13 a position along said road segment at which said location is accessible in said desired

14 direction of travel;

15   identifying a side of said subsegment of the one data record, said side

16 representing a side of said road segment at which said location is accessible in said

17 desired direction of travel; and

18   identifying one of said nodes of said one data record, said one node

19 representing the endpoint of the road segment by which the location is accessible in

20 said desired direction of travel.

21

22   15.   A method of performing a route calculation function using a navigation

23 system that uses a map database that includes road segment records that represent

24 portions of roads in a road network in a geographic region, comprising the steps of:

25   identifying at least one seed gate associated with a first location in said

26 geographic region through which a solution route is constrained to pass, wherein said

27 seed gate comprises an associated locus representing a position along a portion of a

28 road represented by a road segment record and a seed gate target node corresponding

29 to a node of the road segment record, said seed gate target node representing an

30 endpoint of the portion of a road represented by said road segment record by which

31 said location is accessible in a desired direction of travel;

32   expanding said at least one seed gate to form at least one successor gate,

33 wherein each successor gate so formed comprises an associated node corresponding to

1 the target node of the seed gate which was expanded to form said successor gate and a

2 successor gate target node, said successor gate target node corresponding to a node of

3 a road segment record that represents a portion of a road which is accessible in the

4 desired direction of travel between the positions represented by the associated node

5 and the target node of the successor gate;

6   comparing each successor gate formed by said expanding step to corresponding

7 gates associated with a second location in said geographic region through which said

8 solution route is constrained to pass and outputting a solution route if a match is

9 found;

10   if a match is not found in said comparing step, evaluating each successor gate

11 to determine one successor gate having a higher priority than any other successor gate;

12   expanding said one successor gate having the higher priority than any other

13 successor gate to form at least one additional successor gate, wherein each additional

14 successor gate comprises an associated node corresponding to the target node of the

15 successor gate which was expanded to form said additional successor gate and a target

16 node of the successor gate, said target node of said successor gate corresponding to a

17 node of a road segment record that represents a portion of a road which is accessible in

18 the desired direction of travel between the positions represented by the associated node

19 and the target node of the additional successor gate;

20   comparing each successor gate formed by said expanding step to said second

21 location in said geographic region through which said solution route is constrained to

22 pass and outputting a solution route if a match is found; and

23   if a match is not found in said second comparing step, continuing to perform

24 said evaluating, expanding, and comparing steps until a match is found.

25

26   16.   The method of Claim 15 wherein said step of expanding said one

27 successor gate further comprising the steps of:

28   evaluating a rank of a road segment along a potential successor gate; and

29   suppressing from consideration said potential gate if said rank is below a

30 predetermined threshold.

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32   17.   The method of Claim 16 wherein said step of suppressing is performed

33 selectively upon segments meeting predetermined criteria.

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2   18.   A method of performing a rerouting function using a navigation system

3 having a route calculation program that uses a map database that includes road

4 segment records that represent portions of roads in a road network in a geographic

5 region, comprising the steps of:

6   after calculating a solution route from a first location in said geographic region

7 to a second location in said geographic region, wherein said solution route is

8 represented by a list of road segment records, storing an inbound search tree formed of

9 a plurality of gates, wherein each gate represents a physical location on said road

10 network and an accessible direction relative to said physical location, and wherein said

11 plurality of gates in said inbound search tree represent segments of roads of said road

12 network from which said second location is accessible,

13   upon said navigation system having departed from the solution route, providing

14 data representing a physical location of said navigation system; and

15   growing said inbound search tree until at least one successor gate of the

16 plurality of gates in said inbound search tree corresponds to said data representing the

17 physical location of said navigation system.

18

19   19.   A method of providing alternative routes using a navigation system

20 having a route calculation program that uses a map database that includes road

21 segment records that represent portions of roads in a road network in a geographic

22 region, comprising the steps of:

23   after calculating a solution route between a first location in said geographic

24 region and a second location in said geographic region, wherein said solution route

25 comprises a list of road segment records that was obtained by forming at least one

26 search tree formed of a plurality of gates, wherein each gate represents a physical

27 location on said road network and an accessible direction relative to said physical

28 location, incrementing a weighting associated with each of said gates in said at least

29 one search tree that corresponds to said list of road segment records that comprise said

30 solution route;

31   growing a search tree by expanding gates to form successor gates; and

32   evaluating which of said successor gates to select for further expansion using

33 said incremented weighting.

20. A method of providing partial solution routes using a navigation system that uses a map database that includes road segment records that represent portions of roads in a road network in a geographic region, comprising the steps of:

identifying at least one seed gate associated with a first location in said geographic region through which a solution route is constrained to pass, wherein said seed gate comprises an associated locus representing a position along a portion of a road represented by a road segment record and a seed gate target node corresponding to a node of the road segment record, said seed gate target node representing an endpoint of the portion of a road represented by said road segment record by which said location is accessible in a desired direction of travel;

expanding said at least one seed gate to form at least one successor gate, wherein each successor gate so formed comprises an associated node corresponding to the target node of the seed gate which was expanded to form said successor gate and a successor gate target node, said successor gate target node corresponding to a node of a road segment record that represents a portion of a road which is accessible in the desired direction of travel between the positions represented by the associated node and the target node of the successor gate;

comparing each successor gate formed by said expanding step to a second location in said geographic region through which said solution route is constrained to pass;

evaluating each successor gate to determine one successor gate having a higher priority than any other successor gate;

expanding said one successor gate having the higher priority than any other successor gate to form at least one additional successor gate, wherein each additional successor gate comprises an associated node corresponding to the target node of the successor gate which was expanded to form said additional gate and a target node of the successor gate, said target node of said successor gate corresponding to a node of a road segment record that represents a portion of a road which is accessible in the desired direction of travel between the positions represented by the associated node and the target node of the additional successor gate; and

prior to finding a match when comparing each successor gate formed by said expanding step to said second location in said geographic region through which said

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1   solution route is constrained to pass, outputting a partial solution route comprised of a

2   list of segments corresponding to at least some of the gates which had been expanded

3   based upon having a higher priority than any other gate.

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5   21.   A route calculation tool program for use in a navigation system and

6   adapted to calculate a route between a first location and a second location, said route

7   calculation tool program comprising:

8   object logic operatively executed by a processor of said navigation system, the

9   object logic comprising a plurality of independent program objects, wherein each

10   program object receives input data and provides output data according to a property of

11   the program object, wherein said route calculation program comprises:

12   at least one of the program objects comprising a route calculation program

13   object operatively adapted to receive a first waypoint program object representing said

14   first location and a second waypoint program object representing said second location;

15   wherein said route calculation program object further comprises:

16   an outbound search tree program object including at least one seed gate and

17   successor gates thereof, wherein said at least one seed gate represents a position along

18   a road segment from which the first location can be exited, said position derived from

19   said first waypoint program object;

20   an inbound search tree program object including said at least one seed gate and

21   successor gates thereof, wherein said at least one seed gate represents a position along

22   a road segment into which the second location can be entered, said position derived

23   from said second waypoint program object;

24   an outbound priority queue program object including prioritized references to

25   unexpanded gates in said outbound search tree program object; and

26   an inbound priority queue object including prioritized references to unexpanded

27   gates in said inbound search tree program object; and

28   wherein at least one of said search tree program object is adapted to grow by

29   expanding the gates therein to find a solution route when said search tree program

30   objects include at least one common gate.

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32   22.   The invention of Claim 21 wherein said route calculation program

33   object is further adapted to receive a vehicle object containing parameters of a vehicle

1 in which said navigation system is installed, and wherein said route calculation program

2 object utilizes said parameters in selecting gates to be expanded.

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4   23.   The invention of Claim 21 wherein said route calculation object is

5 further adapted to receive a configuration object containing parameters input via said

6 user interface, and wherein said route calculation object utilizes said parameters in

7 selecting gates to be expanded.

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9   24.   A method of providing real time traffic weighted routes using a

10 navigation system having a route calculation program that uses a map database that

11 includes road segment records that represent portions of roads in a road network in a

12 geographic region, comprising the steps of:

13   receiving a wireless transmission indicating weightings applicable to roads in

14 said road network;

15   calculating a solution route between a first location in said geographic region

16 and a second location in said geographic region, wherein said solution route comprises

17 a list of road segment records that was obtained by forming at least one search tree

18 formed of a plurality of gates, wherein each gate represents a physical location on said

19 road network and an accessible direction relative to said physical location;

20   identifying to which of said road segments said weightings apply;

21   incrementing each of said gates in said at least one search tree that corresponds

22 to a road segment to which one of said weightings applies;

23   growing a search tree by expanding gates to form successor gates; and

24   evaluating which of said successor gates to select for further expansion using

25 said weighted gates.

26

27   25.   A method for using geographic data that represents road segments in a

28 geographic region to calculate a route between waypoints, wherein a waypoint

29 represents one of an origin of the route, a destination of the route, and an intermediate

30 stop between the origin and the destination of the route, and wherein each road

31 segment is designated as having a rank selected from a plurality of ranks, and wherein

32 said rank of a road segment is indicative of a functional classification thereof, the

33 method comprising the steps of:

1 starting from one of the waypoints, identifying portions of potential solution

2 routes that connect to said waypoint by identifying road segments that connect to said

3 waypoint directly and by way of other road segments;

4 determining a first radius from said waypoint,

5 suppressing consideration of road segments that have a first specified rank and

6 that are located outside of said radius from being included as parts of said portions of

7 potential solution routes;

8 wherein said first radius is determined based upon the density of road segments

9 around said waypoint.

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11 26. The method of Claim 25 wherein said plurality of ranks includes at least

12 three ranks, and wherein said method further comprises the steps of:

13 determining a second radius from said waypoint, wherein said second radius is

14 greater than said first radius; and

15 suppressing consideration of road segments that have a second specified rank

16 and that are located outside of said second radius from being included as parts of said

17 portions of potential solution routes, wherein said second specified rank is different

18 than said first specified rank;

19 wherein said second radius is determined based upon the density of road

20 segments around said waypoint.

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22 27. The method of Claim 26 wherein said plurality of ranks includes at least

23 four ranks, and wherein said method further comprises the steps of:

24 determining a third radius from said waypoint, wherein said third radius is

25 greater than said second radius; and

26 suppressing consideration of road segments that have a third specified rank and

27 that are located outside of said third radius from being included as parts of said

28 portions of potential solution routes, wherein said third specified rank is different than

29 said first specified rank and said second specified rank;

30 wherein said third radius is determined based upon the density of road

31 segments around said waypoint.

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28. A method for using geographic data that represents road segments in a geographic region to calculate a route between waypoints, wherein a waypoint represents one of an origin of the route, a destination of the route, and an intermediate stop between the origin and the destination of the route, and wherein each road segment is designated as having a rank selected from a plurality of ranks, and wherein said rank of a road segment is indicative of a functional classification thereof, the method comprising the steps of:

starting from one of the waypoints, identifying portions of potential solution routes that connect to said waypoint by identifying road segments that connect to said waypoint directly and by way of other road segments;

as road segments are identified that connect to said waypoint by way of other segments, relating a number of road segments identified to a distance from a recently identified road to the waypoint to determining a density factor around said waypoint;

using said density factor to determine a first radius from said waypoint,

suppressing consideration of road segments that have a first specified rank and that are located outside of said radius from being included as parts of said portions of potential solution routes.

29. An object-oriented route calculation program for finding a solution route between a first location on a road network in a geographic region and a second location on the road network in the geographic region, using a map database that includes road segment data records that represent segments of roads that form the road network, the route calculation program comprised of a plurality of program objects, wherein each program object receives input data and provides output data according to a property of the program object, wherein said route calculation program comprises:

a route calculation program object having the property that,

upon receiving first input data that identifies a first position in the geographic region and second input data that identifies a second position in the geographic region, output data is provided comprising a list of road segment records that represent segments of roads that link to each other to form a continuous navigable route connecting the first location and the second location,

wherein the route calculation program object comprises:

1   a first search tree program object having the property that,

2   upon receiving said first input data, an output is provided identifying a

3   plurality of segments of roads, each of which links in a first desired direction of travel

4   to said first position along a continuous navigable route formed of segments of roads,

5   a second search tree program object having the property that,

6   upon receiving said second input data, an output is provided identifying

7   a plurality of segments of roads, each of which links in a second desired direction of

8   travel, opposite to said first desired direction of travel, to said second position along a

9   continuous navigable route formed of segments of roads,

10   a first priority queue program object having the property that,

11   upon receiving said output data of said first search tree program object

12   and any additions thereto, an output is provided that identifies which one of said

13   plurality of segments of roads has a higher priority relative to any other of said

14   plurality of segments of roads and said additions thereto, if any, based upon an

15   evaluation of each of said plurality of segments of roads against a search criterion;

16   and wherein said first search tree program object has the further property that,

17   upon receiving said data from said first priority queue program object

18   that identifies which one of said plurality of segments of roads has said higher priority,

19   said first search tree program object adds to its previous output at least one segment of

20   a road that is a valid successor of said one of said plurality of segments of roads

21   identified by said first priority queue object as having said higher priority, until one of

22   said segments of roads in said first search tree program object corresponds to one of

23   said segments of roads in said second search tree program object thereby providing

24   said list of road segment records that represent segments of roads that link to each

25   other to form a continuous navigable route connecting the first location and the second

26   location.

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28   30.   In a route calculation program that determines a solution route between

29   a first location in a geographic region and a second location in the geographic region,

30   using a geographic database that includes data records that represent road segments

31   that form a road network in the geographic region, wherein each road segment is

32   designated as having a rank selected from a plurality of ranks, and wherein said rank of

33   a road segment is indicative of a functional classification thereof, and wherein the

1   solution route includes a list of road segments that connect via the road network

2   between the first location and the second location,

3   wherein the route calculation program evaluates successor road segments of at

4   least one road segment upon which one of said positions is located and successor road

5   segments thereof to find a plurality of road segments that connect via the road network

6   to the other of said positions, and

7   wherein during the process of evaluating successor road segments, a plurality

8   of partial solution routes are developed, wherein each of said partial solution routes

9   comprises a plurality of road segments connecting the one of said positions to a road

10   segment whose successor road segments have yet to be evaluated;

11   wherein during the process of evaluating successor road segments, the route

12   calculation program maintains a list of said road segments whose successor road

13   segments are yet to be evaluated;

14   wherein an improvement comprises:

15   defining a focus ring area bounded between an inner radius corresponding to a

16   distance of the road segment closest to a point of focus toward which said successor

17   road segments are evaluated and an outer radius corresponding a focus ring width; and

18   suppressing from evaluation any road segments whose successor road segments

19   are yet to be evaluated that have a rank less than a highest rank.

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